# Observing very low column density HI within the Local Group

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Wolfe et al. (2013), Nature, 497, 224
Wolfe et al. (2016), ApJ, 816, 81

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# Outline

Background
- Diffuse Gas in the Local Group

GBT Observations
- Between M31 and M33
- Northwest of M31

Results
- Discrete Gas Clouds
- Emission North of M31

Discussion
- Possible Origins
- Future Work

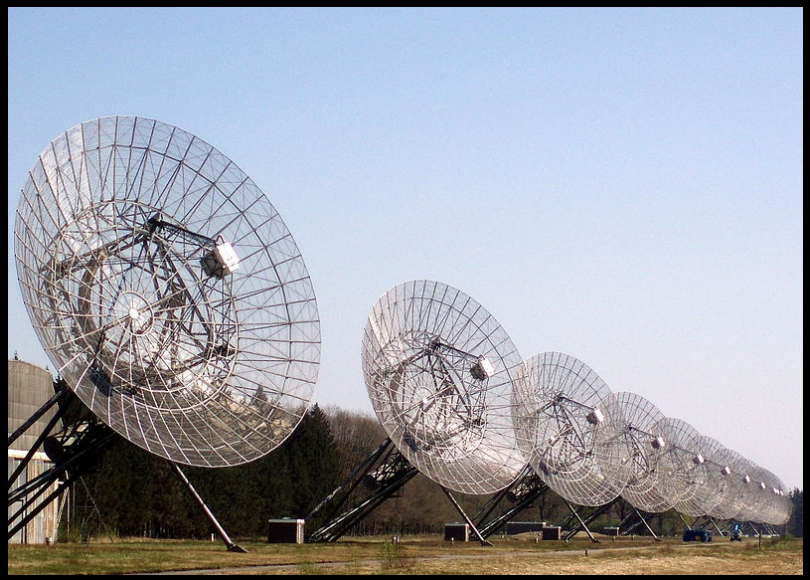
# Faint HI in the Local Group

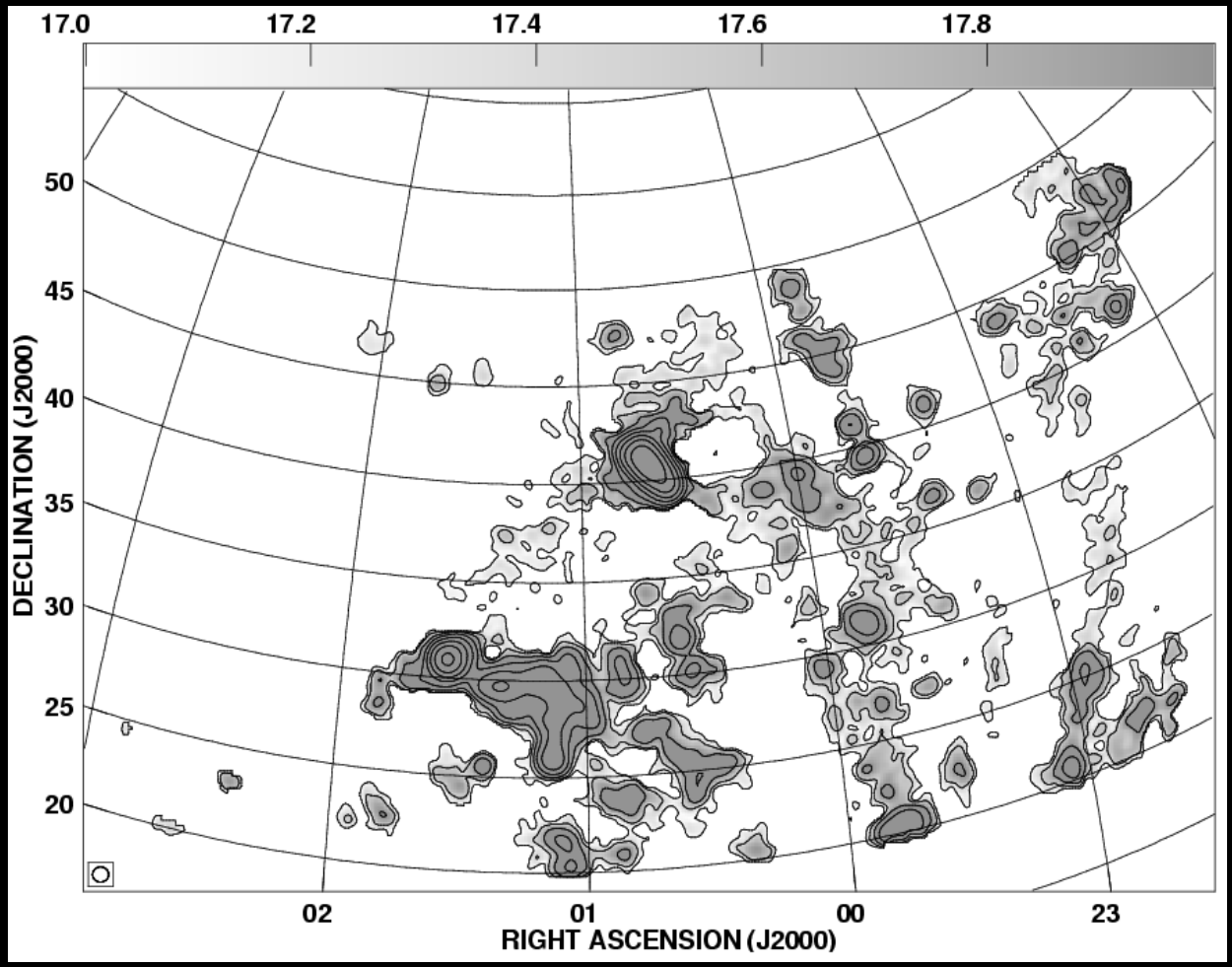
Braun & Thilker (2004, BT04)

Westerbork Synthesis Radio Telescope – each dish as a separate antenna

Survey of HI in the Local Group

$\log(N_{HI}) = 17.0\ cm^{-2}$ (2-3σ)






Braun & Thilker (2004), A&A, 417, 421-435

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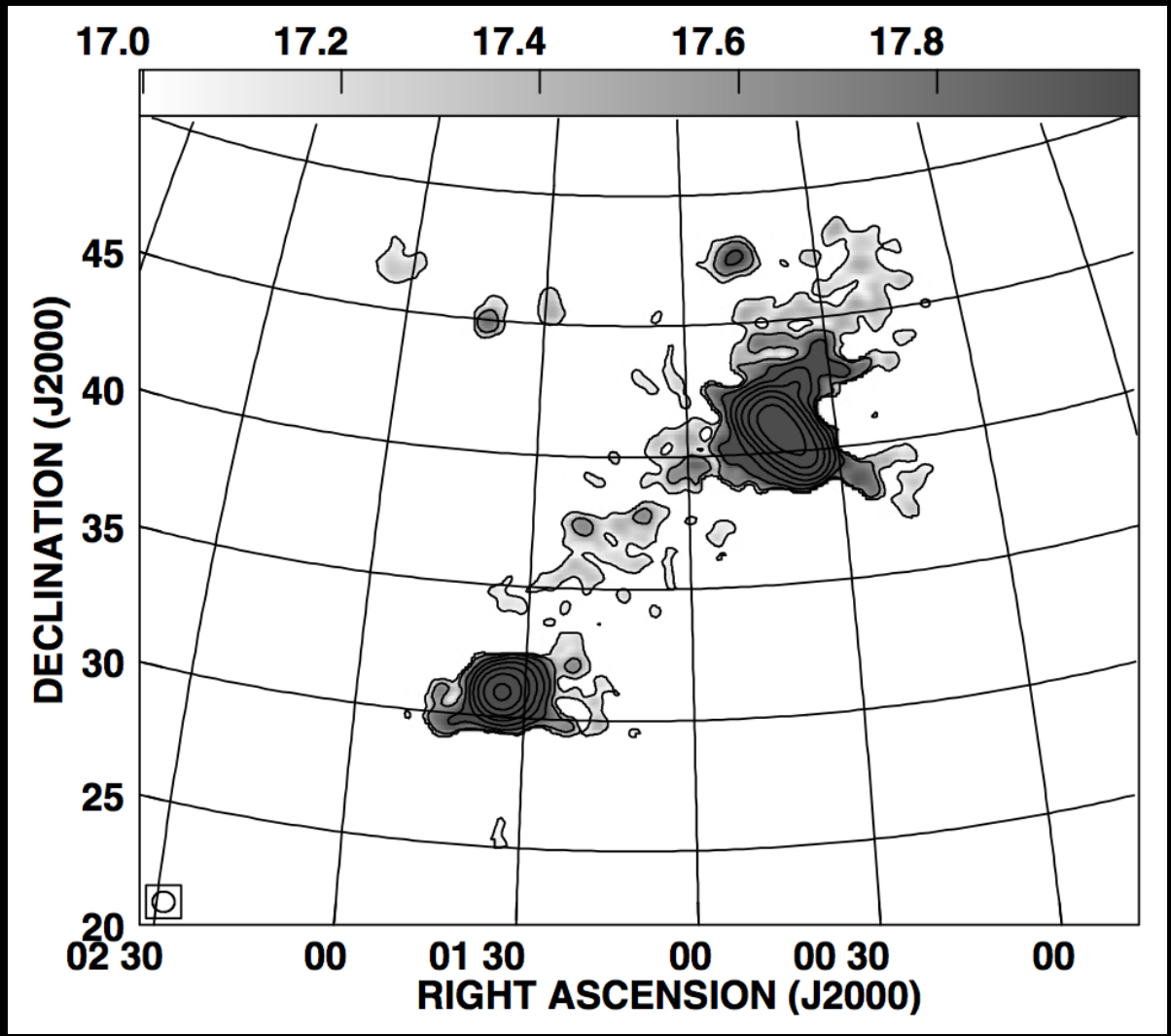
# Faint HI in the Local Group

HI between M31 & M33, and to the northwest of M31.

VERY faint emission.
$N_{HI} \sim 1 \times 10^{17}$ cm$^{-2}$ (2-3σ)

Part of an intergalactic filament, or a tidal feature?

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# A Deep GBT Survey

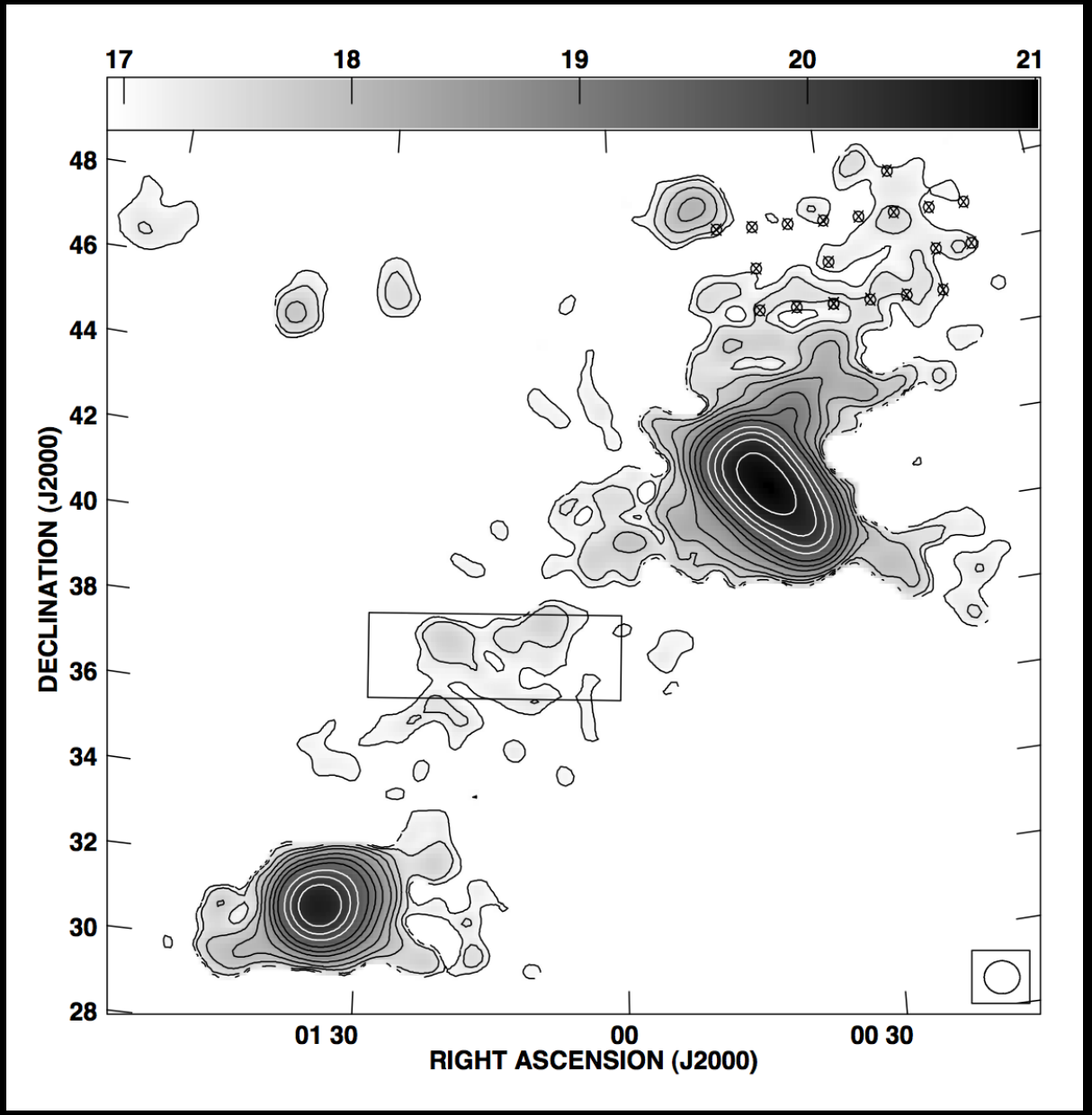
12 square degrees between M31 and M33.

$N_{HI}$ ~ 2 x $10^{17}$ $cm^{-2}$

9' GBT beam, 5 km/s

Deep pointings to the northwest of M31.

Other maps being reduced.

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# The GBT

100 m diameter.

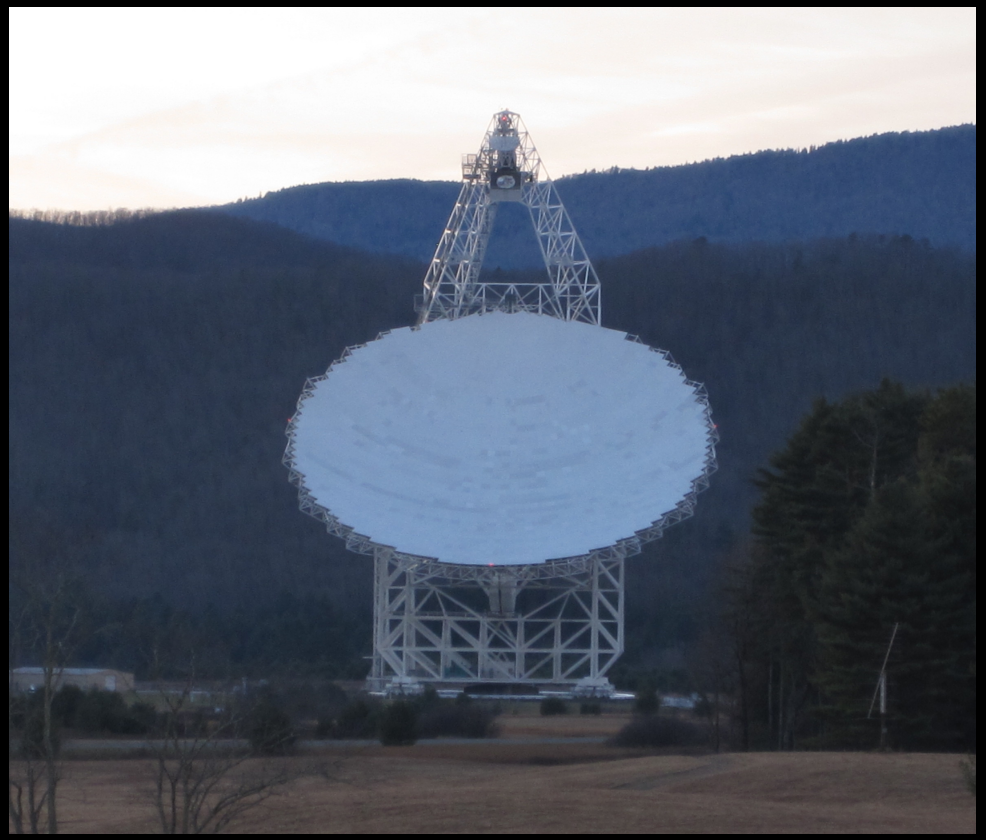
Largest fully steerable radio telescope in the world.

Very low contribution from “stray” radiation.

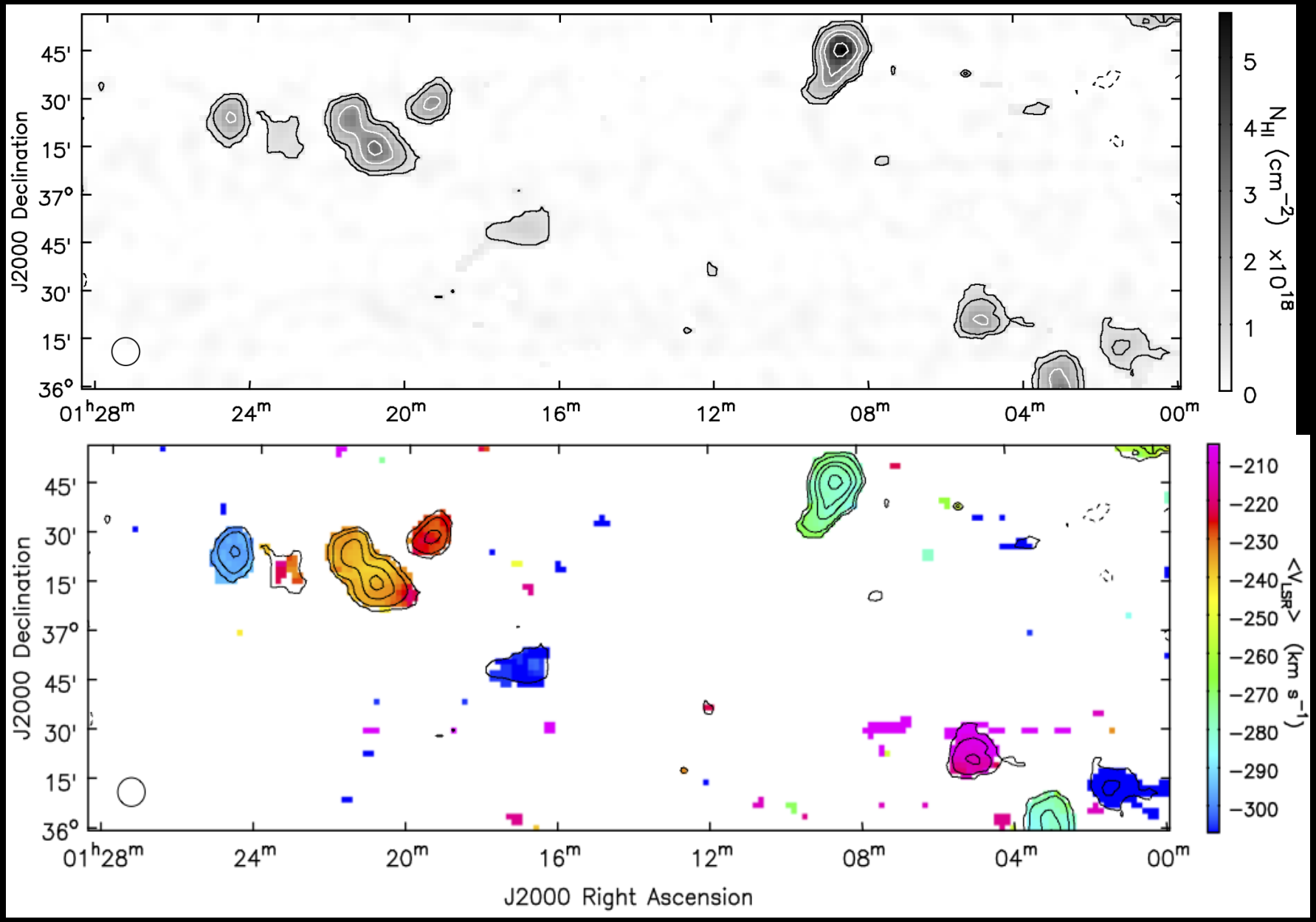
Low system temperatures.

National Radio Quiet Zone.

Image credit: Me



# Results: Between M31 and M33




Wolfe, Lockman & Pisano (2016)

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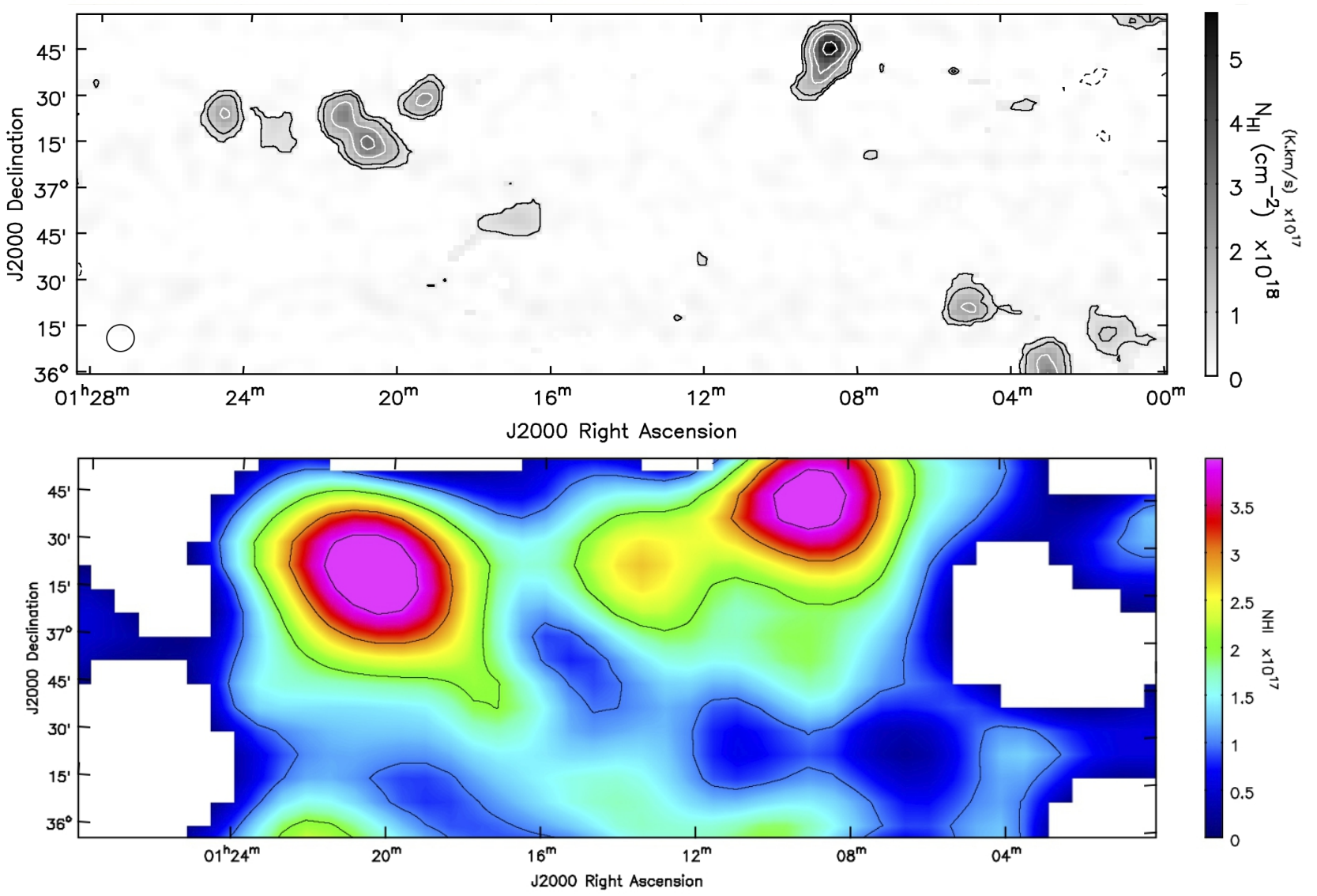
# Results: Between M31 and M33




We report 63% of the HI mass from Braun & Thilker (2004)

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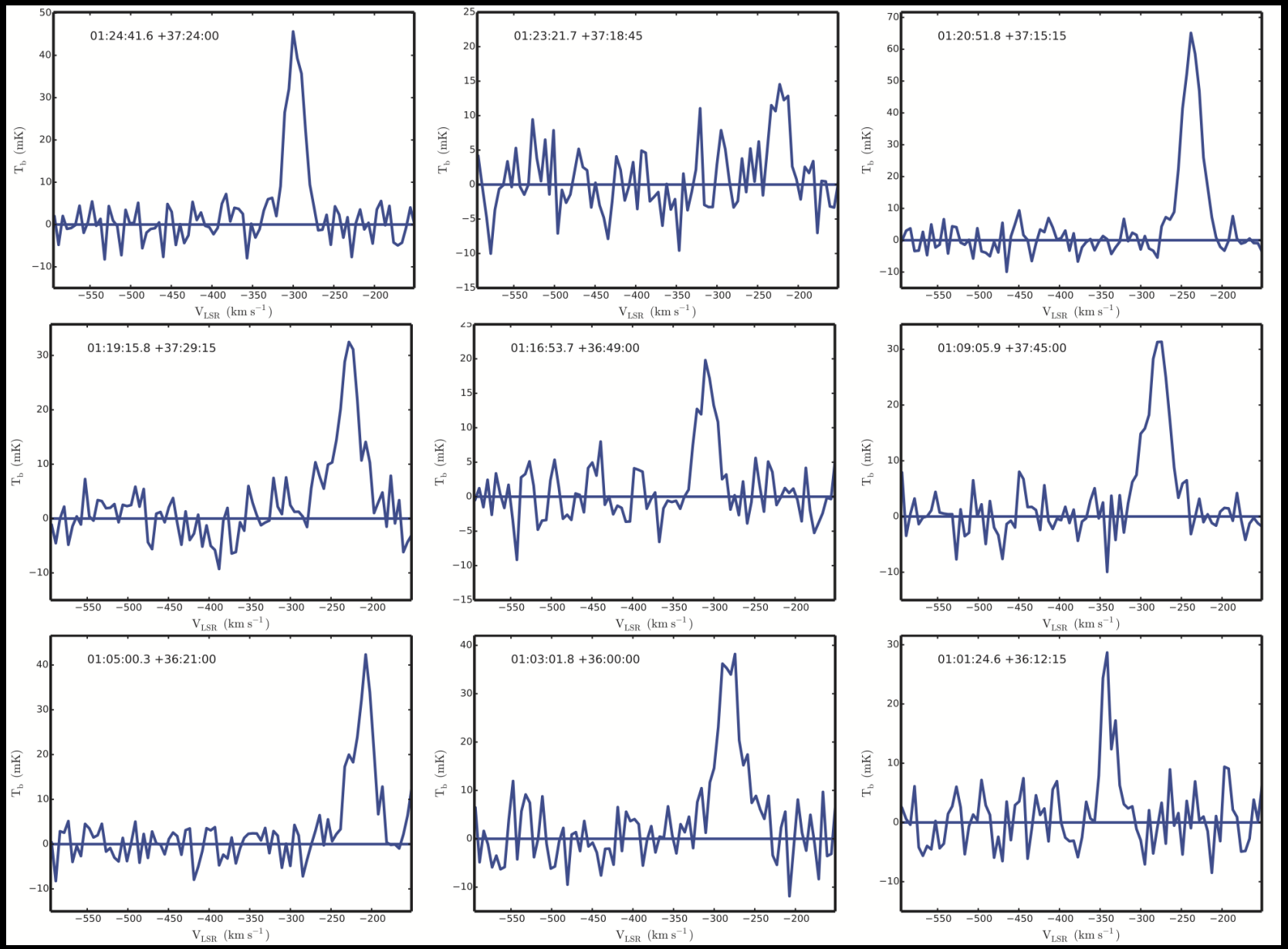
# Results: Between M31 and M33




Wolfe, Lockman & Pisano (2016)

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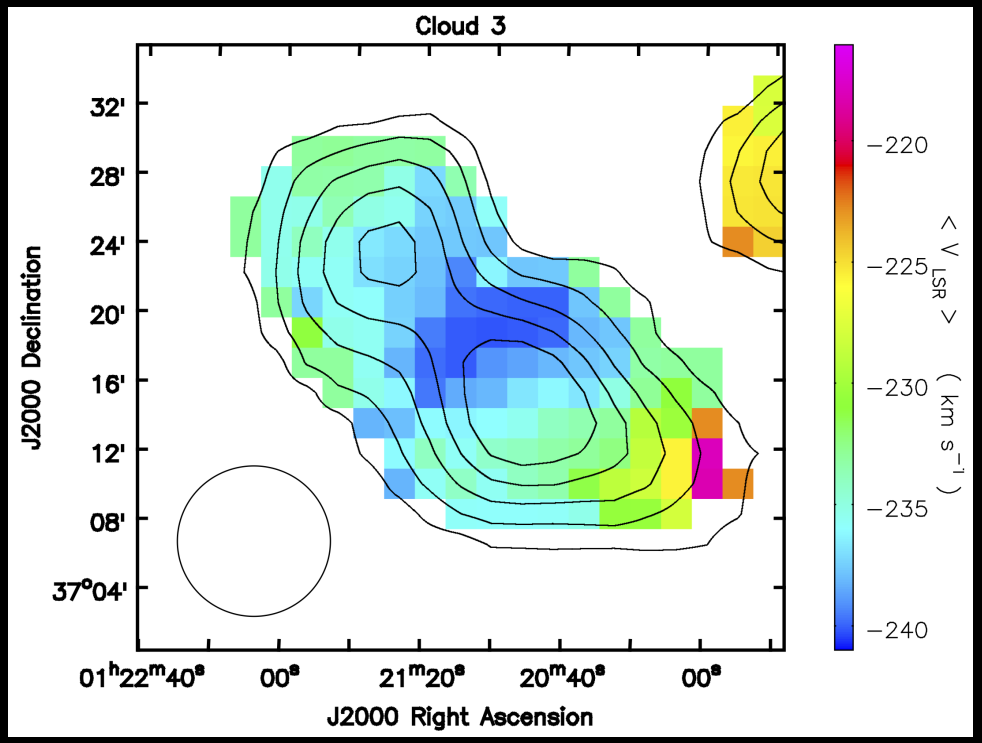
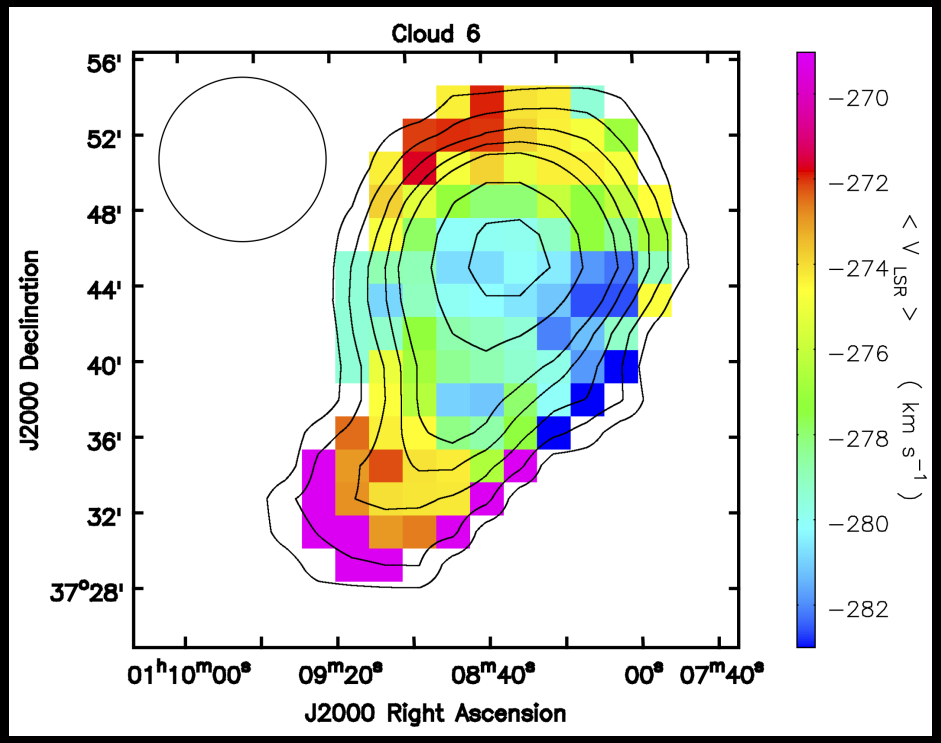
# Results: Between M31 and M33




Wolfe, Lockman & Pisano (2016)

<u>Assuming D ~ 800 kpc</u>

Peak Column: $2 \times 10^{18}$ cm$^{-2}$

FWHM: 19 - 39 km s$^{-1}$

$M_{HI}$: $4.5 – 39 \times 10^{4}$ $M_{SUN}$

Size: 0.4 – 1.1 kpc

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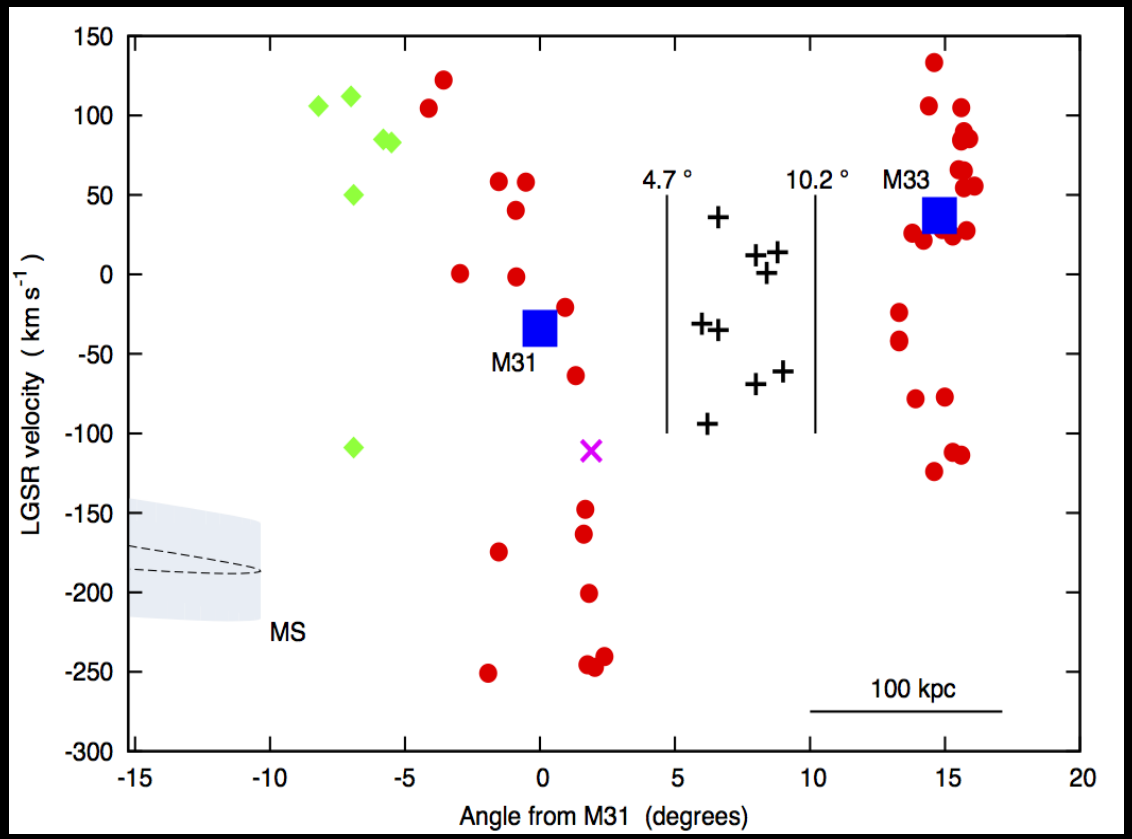
# What are these objects?

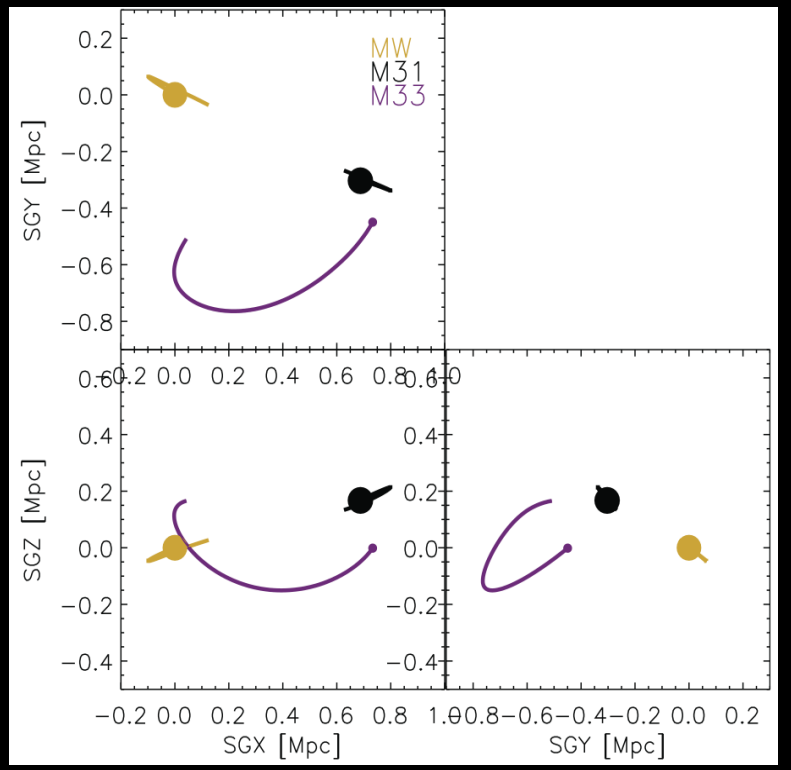
A tidal interaction?

Bekki (2008), McConnachie(2009), etc.

Shaya & Tully (2013) – Not within the past 12 Gyr.

Lack of stars (Martin et al. 2013).




High Velocity Clouds?

Clouds lie ~ 100 kpc from either galaxy.

Smaller spread in velocity.

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# What are these objects?

Dwarf Galaxies?

Should see stars with these objects (PAndAS).
One faint detection (Martin et al. 2013)

Dwarves HI deficient within 300 kpc.
(Spekkens et al. 2014, Nickerson et al. 2011)

# What are these objects?

Condensations from a filament?

Nuza et al. (2014)

Scannapieco et al. (2015)

Condensations from M31's halo?

Lehner et al. (2015)

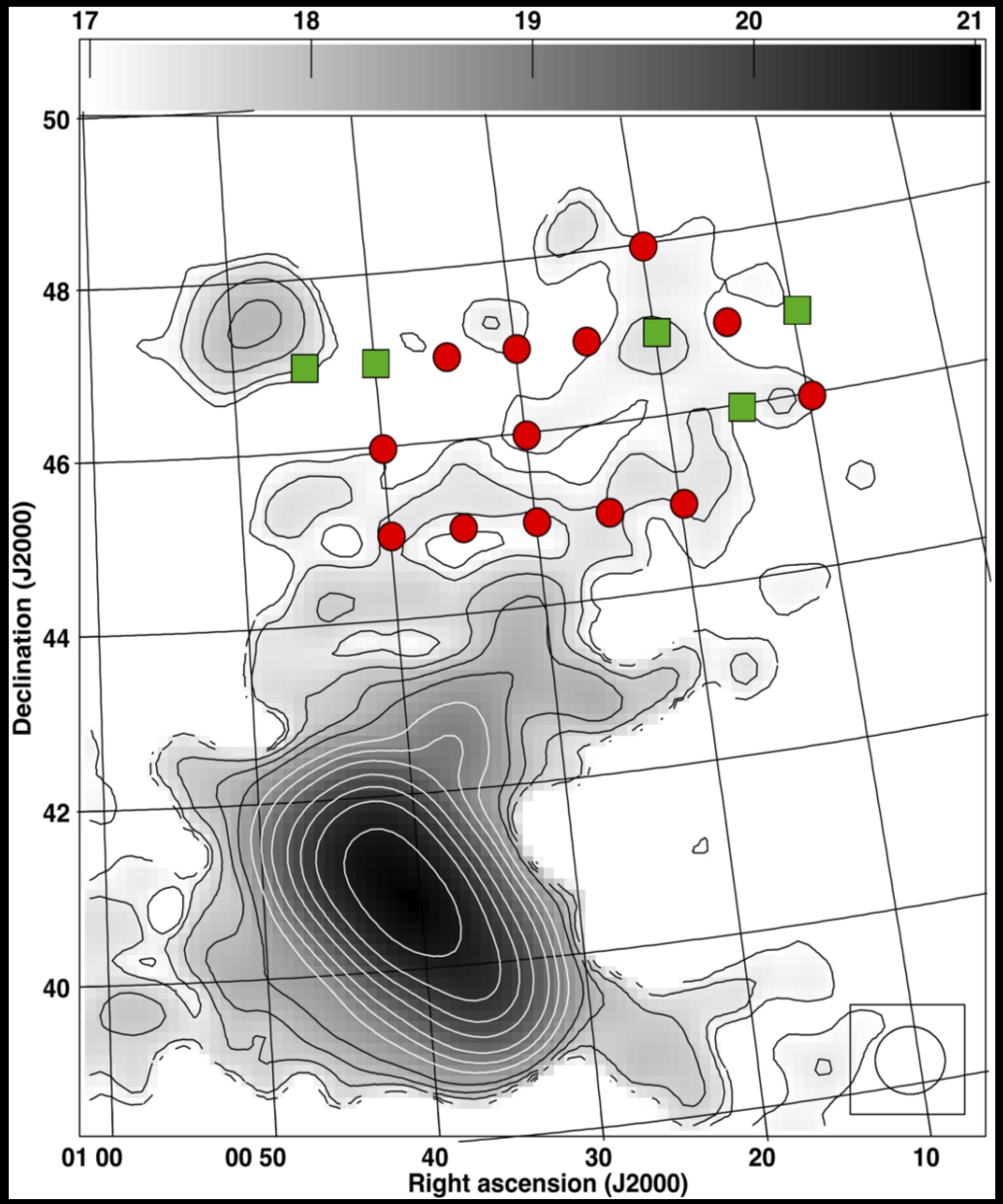
# To the Northwest of M31

18 pointings
Frequency switched

Five detections

Emission is patchy?

Confusion with Milky Way?

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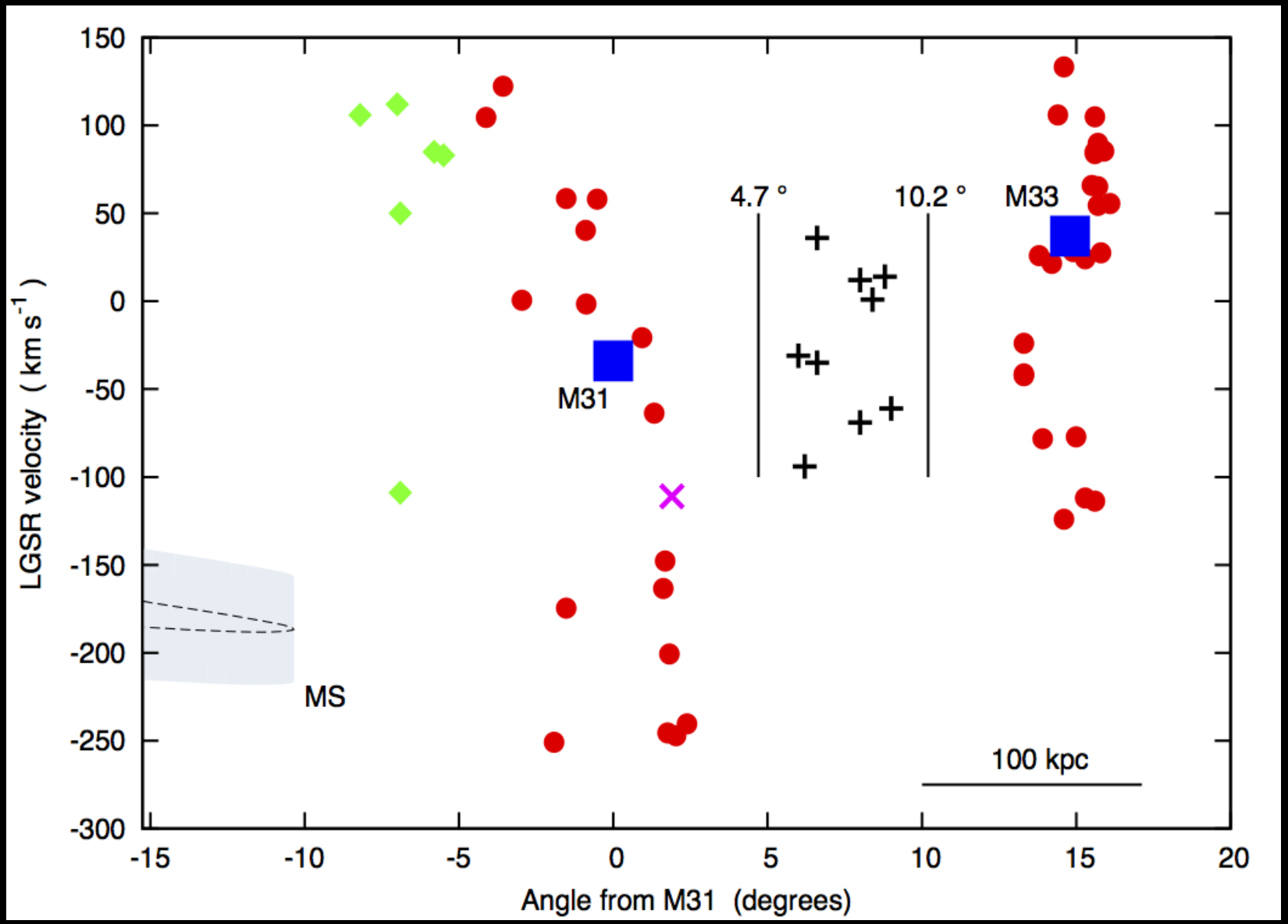
# To the Northwest of M31




Wolfe, Lockman & Pisano (2016)

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# Conclusions

Faint HI between M31 and M33  (HI clouds)

Properties unique to the Local Group

Origins still a mystery

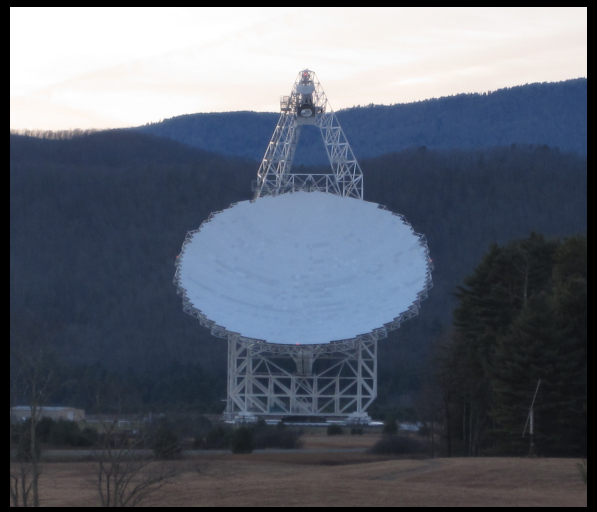
Faint HI confirmed to the northwest

Likely part of M31's HVCs or foreground Milky Way

Mapping data will be reduced and written up soon.

# Future Work

Reduction of all GBT survey data.
Map closer to M31 (~ 150 hours)
Map to the northwest ( < 100 hours)



VLA time awarded for the brightest HI cloud ( ~ 6 hours)

Further mapping.

Image credit: Me

Project  AMIGA.